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CONTROL APPARATUS FOR STEAM HEATING SYSTEMS

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FIG. 1

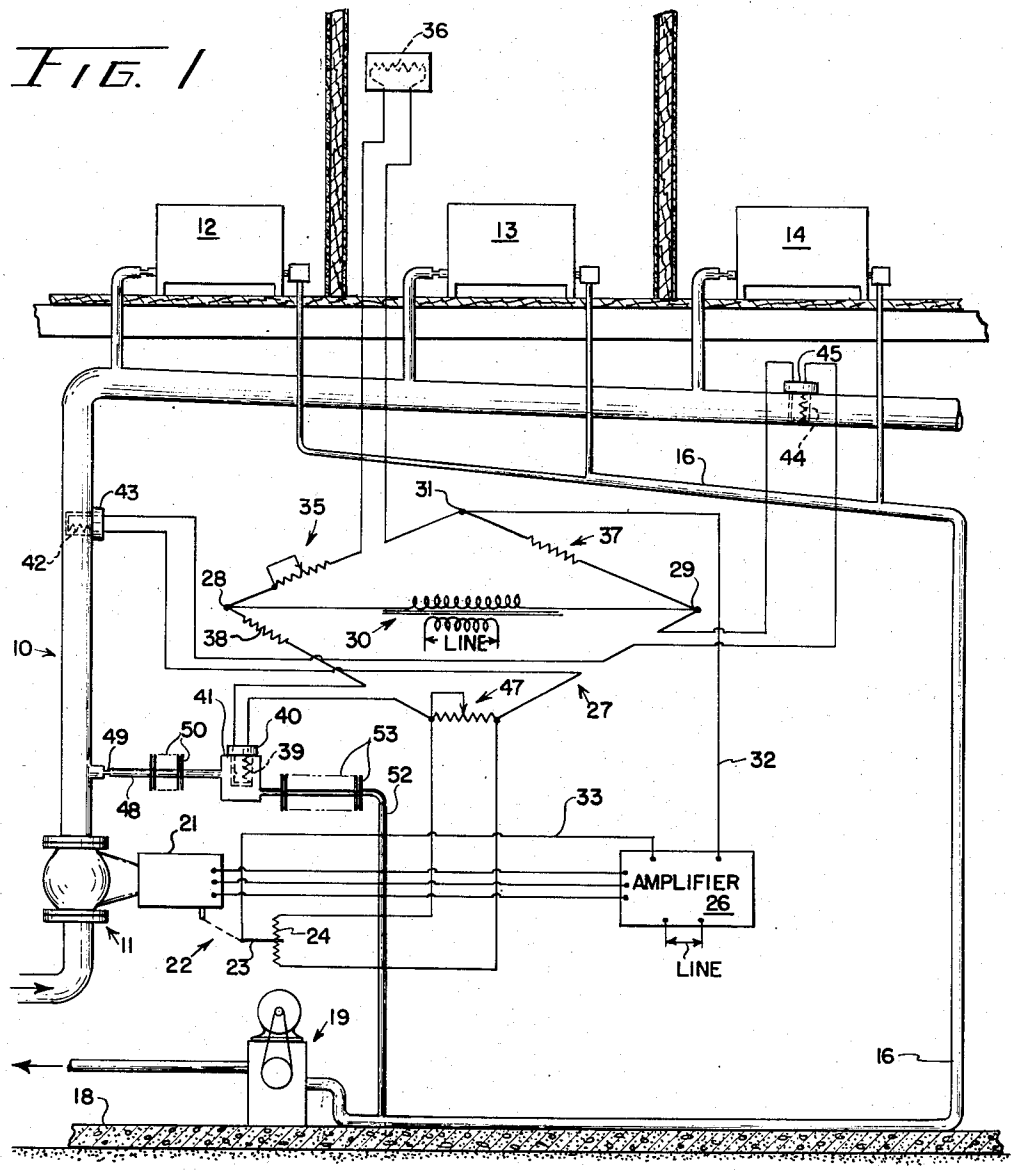
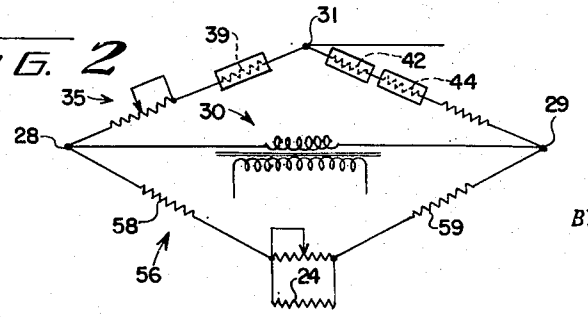


FIG. 2



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CONTROL APPARATUS FOR STEAM HEATING SYSTEMS

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1

The present invention relates to temperature control apparatus for a steam heating system. Conventionally, steam heating systems are controlled, at least in part, by pressure responsive devices with a thermostat of some sort exercising dominant control. These prior art arrangements are generally effective but costly. Further, in cases where the steam supply is superheated, a pressure measurement of the steam does not accurately reflect its heating ability. Some attempts have been made to control steam heating systems entirely by temperature responsive devices but, where it is necessary to determine a return line temperature, the results have not been satisfactory because of a tendency for the return line to become sub-cooled due to its exposure conditions.

The present invention overcomes these difficulties by averaging the supply temperature and by providing a temperature responsive device exposed to saturated steam at the pressure of the return line. By this arrangement, temperature of the supply is accurately taken into account and a temperature is obtained for the return line that properly indicates the influence of return pressure on the system but which is unaffected by the exposure conditions of the return line. It is thus a major object of this invention to provide improved control apparatus for a steam heating system.

It is a further and more specific object to provide a practical differential temperature control system for a steam heating system wherein the differential may be maintained constant or may be varied as desired.

It is an additional object to provide means for establishing a temperature which accurately reflects the return line pressure.

These and other objects will become apparent upon a study of the following specification and drawings in which:

Figure 1 is a schematic showing of a steam heating system equipped with the present control apparatus.

Figure 2 is a modified network circuit which may be used in the system of Figure 1.

In the system shown in Figure 1, steam is supplied through main 10 from a suitable boiler or central heating system, the flow of steam being controlled by a motor valve 11. The steam is taken from the main 10 to the various radiators, 12, 13 and 14 through individual risers and orifices in a conventional manner, these radiators being representative of a conventional steam heating system. In addition, radiators 12, 13 and

2

14 are connected through suitable traps and return risers to a return main 16 which extends down to the basement floor 18 and runs along this floor until it reaches condensate pump 19 from which it is delivered to the boiler. Pump 19 is preferably controlled by its own controller, not shown, responding to return line pressure. While the present system is shown with orifices and traps, it seems obvious that other means for controlling the steam distribution among the various radiators may be used and the traps may be eliminated if desired, neither of these features being necessary in the performance of this invention. The motor 21 which operates motor valve 11 is preferably of the proportioning type and includes a follow-up potentiometer 22 having a wiper 23 movable over a resistor 24. Motor 21 is controlled by amplifier 26 which may be of any suitable type capable of discriminating the phase relations of its input signals so that it can properly control a reversible motor such as 21. As an example of a motor and amplifier found suitable in this apparatus, reference is made to Patent No. 2,423,534 issued to Albert P. Upton July 8, 1947. As in the Upton patent, amplifier 26 is controlled by a bridge type network circuit generally identified by the numeral 27, network 27 having input terminals 28 and 29 connected to the secondary winding of a transformer 30, and the network also includes an output terminal 31 with wiper 23 constituting the other output terminal. Output terminal 31 is connected to the input of amplifier 26 by wire 32 and wiper 23 is connected to the input of the amplifier by the wire 33. The upper left hand branch of network 27 comprises a manually adjustable resistor 35 and a temperature responsive resistor 36 arranged in one of the rooms of the building being heated, a representative room being selected for this purpose. The upper right hand branch of the network comprises a fixed resistor 37, and the lower left hand branch of the network includes a fixed resistor 38 and a temperature responsive resistor 39 arranged in a protective well 40 which in turn is received in a steam chamber 41, with resistor 39 and 38 approximating in resistance value the fixed resistor 37. Chamber 41 is essentially only a sufficiently enlarged portion of conduit 48 to receive well 40 and to permit steam to surround the well. The lower right hand branch of the network comprises a temperature responsive resistor 42 received in a well 43 inserted in main 10 and also includes a similar fixed resistor 44 in well 45 which is inserted near a remote portion of main

10. For the purpose of this illustration, the total resistance value of resistors 42 and 44 approximates that of resistors 35 and 36, under normal conditions. Resistor 24 is connected across the lower branches of the network and an adjustable resistor 47 is connected in shunt relation to resistor 24.

The steam chamber 41 in which resistor 39 is located is connected to supply main 10 by a conduit 48, an orifice or similar restriction 49 limiting the flow of steam through this conduit, this orifice being only large enough to avoid plugging for only a small flow of steam is needed for element 39. In addition, suitable fins or the like 50 may be attached to conduit 48 to insure that some condensation will take place in the conduit before reaching chamber 41, to thereby assure that saturated steam will be provided for chamber 41. As an alternative to fins 50, the conduit between orifice 49 and chamber 41 may be lengthened or other provisions made to insure some condensation in the conduit. The bottom portion of chamber 41 is connected through conduit 52 to return main 16 upstream from the suction side of pump 19. Fins 53 or the like are used on conduit 52 to make certain that all of the steam remaining in the conduit after passing through chamber 41 will be condensed before reaching pump 19. While fins 50 and 53 are used on conduits 48 and 52, respectively, it is obvious that any means of insuring sufficient condensation will be adequate and it is unimportant if some steam still remains in conduit 52 if the connection to the return line 16 is far enough away from pump 19 so that the condensate flowing in main 16 will condense the steam before it reaches the pump so that operation of the pump will not be impaired.

With the arrangement above described, it will be apparent upon inspection that network 27 is arranged to maintain a predetermined balance in resistance between the lower portions of the bridge, assuming that the upper portions are fixed. However, upon a change in resistance of either resistors 35 or 36 or both, then a different state of balance must be maintained in the lower branches of the network to keep the bridge in balance so that the system, as shown, operates to vary the operating differential temperature of the system upon a change in room temperature. Thus, a lower room temperature will call for an increased temperature differential and a higher room temperature will call for a decreased temperature differential in the system. If desired, resistor 36 may be made part of an outdoor controller or other such device for determining system load, a room temperature device being shown for the purposes of illustration.

A slightly modified arrangement of the above system is sometimes desirable, especially for zone control, and network circuit 56 shown in Figure 2 shows schematically a modification. In this case, assuming that the input and output terminals are the same as above, the upper left hand branch may comprise manually adjustable resistor 35 and temperature responsive resistor 39; the upper right hand branch includes temperature responsive resistors 42 and 44 and the lower branches of the network include fixed resistors 58 and 59, with resistor 24 of follow-up potentiometer 22 being connected across these lower branches as in the preceding example. With this arrangement, the system will control to maintain a fixed differential of temperature between the supply resistors and the return temperature responsive resistor, with the valve of the differential being determined by the manually adjustable resistor 35.

Operation

To more fully illustrate the present invention, its operation will now be discussed. Assuming that steam is flowing through main 10, valve 11 is partly open and radiators 12, 13 and 14 are receiving steam and discharging condensate through return main 16, it may further be assumed that the system is in equilibrium. With pump 19 running and, as usual in such systems, under the control of a return line pressure controller, it operates to maintain the return line pressure between predetermined values. These predetermined values may comprise a rather narrow range of pressure or, if less frequent starting and stopping of the pump 19 is desired, the values may be somewhat more widely separated. With the system in operation as described, steam is not only flowing through the conventional portions of the system in the ordinary fashion, but it is also flowing through orifice 49 into conduit 48 in rather small quantities, some of this steam being condensed due to the cooling effect of fins 50, with the steam and condensate being delivered to chamber 41 which surrounds well 40, so that resistor 39 responds to the temperature of the saturated steam in the chamber 41. However, because conduit 52 is connected to the bottom of chamber 41 and is also connected to main 16 and has no appreciable restrictions in its length, the pressure in chamber 41 is substantially the same as that in return line 16, hence bulb 39 is responding to a temperature of saturated steam existing at the pressure in the return line and, as is well known, where saturated steam is used, there is a definite relation between pressure and temperature under all conditions. Assuming that pump 19 is running, it is obvious that it will tend to reduce the pressure in line 16 and, when this pressure is reduced to the cut-off point of the pump, the pressure in chamber 41 is likewise reduced, with a consequent reduction in the temperature of the steam. Because of the lowered temperature in 41, bridge 27 tends to be unbalanced due to the lower resistance in the lower left branch of the network. Due to this unbalance, the output terminals of network 27 are at a different voltage and there is a predetermined phase relation between them. This is effective to cause amplifier 26 to control motor 21 in a direction to reduce steam flow to thereby reduce the temperature at resistors 42 and 44, thus tending to bring the bridge back in balance. In addition, as the motor 21 operates, wiper 23 is adjusted over resistor 24 in a direction to reduce the unbalance of the network, as is common in proportioning circuits. Depending on the speed of operation of motor valve 11 and the response of the system to adjustments of the valve, resistor 47 is adjusted to give only enough authority to potentiometer 22 to keep the system stable and, in many cases, resistor 47 may be adjusted to a position in which potentiometer 22 has no effect so that the system then becomes, in effect, a floating type of control apparatus. Regardless of whether the system operates in a floating manner or in a proportioning manner, it is obvious that as the return temperature goes down, the supply temperature must also go down, assuming that the room temperature responsive resistor and the fixed resistor 35 remain unchanged. As these temperature differences reflect pressure differences, it is obvious that the rate of flow of steam into the radiators

then remains constant because the rate of flow is essentially a function of pressure difference and the total output of the heating system is much more sensitive to changes in the rate of flow than it is to minor variations in the temperature of the steam being supplied.

Upon the pump 19 stopping, it is obvious that the pressure in the return line 16 will tend to build up gradually so that the pressure in 41 likewise builds up and so does the temperature, with a resultant increase in resistance of resistor 39. The increase in resistance of 39 tends to unbalance the bridge in an opposite direction from that previously experienced with the result that amplifier 26 controls motor 21 in a direction to increase the flow of steam and thereby raise the temperature of resistors 42 and 44 and, as a result, by keeping the differential temperature constant the differential pressure is also kept constant with the rate of flow of steam through the radiators being maintained in equilibrium.

If the temperature of resistor 36 should now decrease, the network will be unbalanced in a direction requiring an increase in resistance of the lower right hand branch or a decrease in the resistance of the lower left hand branch, or both, to restore the balance and, until the balance is restored, the network feeds signals to amplifier 26 of a sort causing motor 21 to adjust valve 11 in a direction to increase the flow of steam, this increase causing a rise in temperature of resistors 42 and 44 to thereby restore the balance of the network. In a similar fashion, an increase in temperature of resistor 36 will cause an unbalance of the network in a direction requiring less resistance in the lower right hand branch of the network or an increase in the temperature of the lower left hand branch, or both, to thus lower the differential temperature being maintained; lower the differential of pressure across the radiators, and thereby cause a lesser rate of heat generation in the spaces.

In the above discussion, it seems clear that resistors 42 and 44 act in an averaging manner but, where the system supply main is generously sized so that uniform pressures are maintained throughout the main, these two resistors may be combined in a single device of equal authority without affecting the operation of the system at all providing that the single resistor and its well be placed far enough down the stream from the valve to not be unduly affected by the normal super heat resulting when steam is expanded or, in cases where considerable superheat is used, a single resistor may be used if placed at a representative spot. However, where there may sometimes be considerable superheat in the steam at the discharge side of the valve, the averaging bulbs are preferred with the downstream bulb preferably having more authority in the system, due to more resistance, than the upstream bulb.

In operation, the system function using the network 56 shown in Figure 2 will be the same as that above discussed with the exception that the differential maintained is normally adjusted only by resistor 35, the system operating to maintain a fixed differential of temperature at all times.

As a study of the preceding specification and drawings will suggest many substitutions and equivalents, the scope of this invention should be determined only by the following claims.

I claim:

1. In a steam heating system including heat exchange means for a space and having a source of steam and a return means, means for controlling the supply of steam from said source, pump means for insuring the return of condensate through said return means and for determining the return means pressure, said return means being of such nature that under at least some conditions of operation the condensate in the return means is sub-cooled, a chamber connected to said return means in such manner that the pressure therein corresponds to that in said return means, a restricted conduit connected between said source of steam and said chamber, said conduit including sufficient heat exchange surface to condense a portion of the steam supplied to said chamber from said source, means responsive to the temperature of the steam supplied from said source, means responsive to the temperature in said chamber, and means connecting both of said temperature responsive means in joint controlling relation to said means controlling the supply of steam, said connecting means being arranged to control said supply controlling means in a manner to maintain a predetermined difference in temperature between the temperature responsive means of said supply and of said chamber, said connecting means including means for varying said predetermined temperature difference.

2. A system as recited in claim 1 wherein the means for varying said predetermined temperature difference comprises a device responsive to the temperature of said space.

3. A system as recited in claim 1 wherein the means for varying said predetermined temperature difference comprises manually operable means.

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